Military Satellites Gain Vital Data

U.S. reconnaissance effort yields precise information on Soviet, Red Chinese strategic weapons after trouble-filled beginning

By Philip J. Klass

Washington—U.S. military reconnaissance satellite program is operating with near clock-like precision less than a decade after a trouble-filled beginning and is providing top government officials with remarkably precise data on Soviet and Red Chinese strategic weapons.

This explains why Defense Dept. figures on Soviet ICBM deployment made public during the Safeguard anti-ballistic missile system debate are not questioned by ABM critics although they challenge Defense Secretary Melvin R. Laird's interpretation of Soviet intent.

Analysis indicates that present photo and electromagnetic reconnaissance spacecraft are third or fourth generation designs which are considerably more complex than models launched in the very early 1960s. For example, current designs have cloud-cover sensors to prevent them from wasting film on targets obscured by weather, a valuable feature not found on the first photo satellites.

Real-time Capability

Still more advanced designs in the future are expected to provide real-time photo and electromagnetic reconnaissance. Photos or electromagnetic signals will be relayed via another satellite to earth stations while the spacecraft is still in orbit. This upcoming capability helps to explain the Pentagon willingness to abandon the USAF's manned orbiting laboratory (MOL) (AW&ST June 16, p. 29).

Since late 1961, the U.S. has been as secretive as the USSR about its reconnaissance satellite effort. Prior to that time, the U.S. made no effort to hide the first three launches of the Samos photo reconnaissance satellite, only one of which went into orbit, on Jan. 31, 1961.

Despite this secrecy, it is possible usually to identify most reconnaissance satellites and to deduce their function from the bare orbital parameters which all countries are obligated to report to the United Nations. The periodic satellite situation reports, prepared by the USAF and published by the National Aeronautics and Space Administration and Britain's Royal Aircraft Establishment, reveal the time-in-orbit for each satellite which also helps to identify its function.

The photo-reconnaissance satellites launched by the U.S. and USSR are generally marked by an extremely low perigee, in the range of 90-125 mi., to achieve maximum possible resolution. U.S. electromagnetic ferret satellites generally operate in near-circular orbits at 200-300 mi.

While all Soviet photo-recon satellites are recovered for photo analysis after approximately eight days in orbit (AW&ST Dec. 9, 1968, p. 83), the U.S. employs two basic types for photographic purposes. Each has a different duration in orbit. These include:

- Area surveillance satellite, with a wide-angle, lower-resolution camera system, is designed to search the large expanses of the Soviet Union and Communist China for objects of potential interest. This type spacecraft usually remains in orbit for three to four weeks before its film payload re-enters and is recovered by USAF/Lockheed C-130 aircraft for analysis. This type satellite originally was launched by a McDonnell Douglas/Lockheed Thor/Agena booster and more recently by improved versions including the Thrust Augmented Thor (TAT) with three strap-on Thiokol Castor 2 solid rockets, and recently by the Long-Tank TAT, or LTAT.
- Close-look satellite, with high-resolution and relatively narrow-field of view camera, is designed to re-photograph areas of interest spotted on the large-area surveillance photos. These satellites, larger than the other type, normally are launched into a near-polar orbit and remain there for no more than five days before payload recovery. First models were launched by a General Dynamics/Lockheed Atlas/Agena, with a transition to the Martin/Lockheed Titan-3B/Agena-D starting in mid-1966.

Mid-air film capsule recovery is also employed.

Lockheed Missile & Space Co. is the prime contractor for both photo reconnaissance satellites.

Program Maturity

Analysis of U.S. launches starting in 1962 (see chart, p. 56), reveals that while the reconnaissance satellite program undoubtedly was producing valuable intelligence in the early 1960s, it appears to have reached operational maturity around 1965-66.

For example, in 1962-64, there often were two of the smaller area-surveillance satellites in orbit simultaneously. This prompts speculation that the redundant spacecraft might have been launched because of reliability problems with the one already in orbit, although there are other possible explanations.

Since early 1966, the U.S. has orbited 8-9 of the smaller photo-reconnaissance satellites per year, with virtually no

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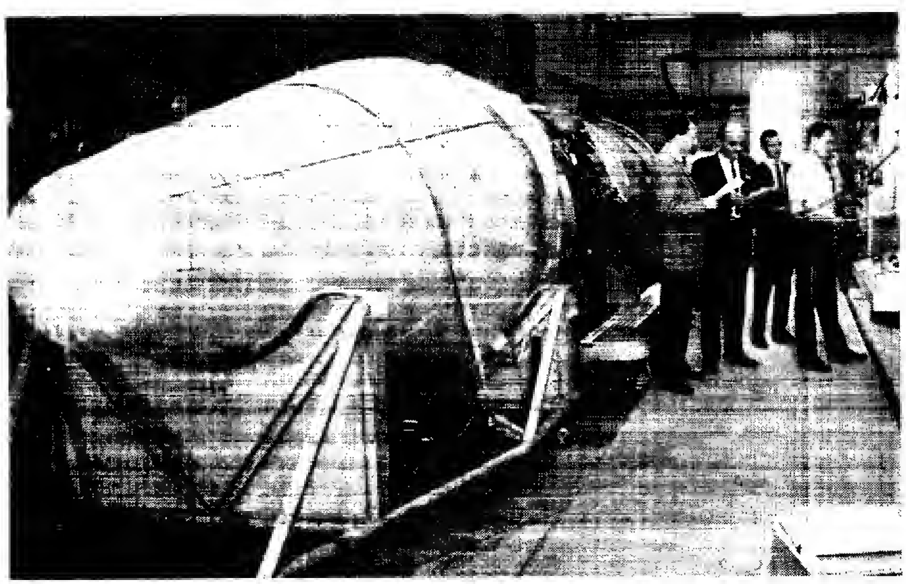
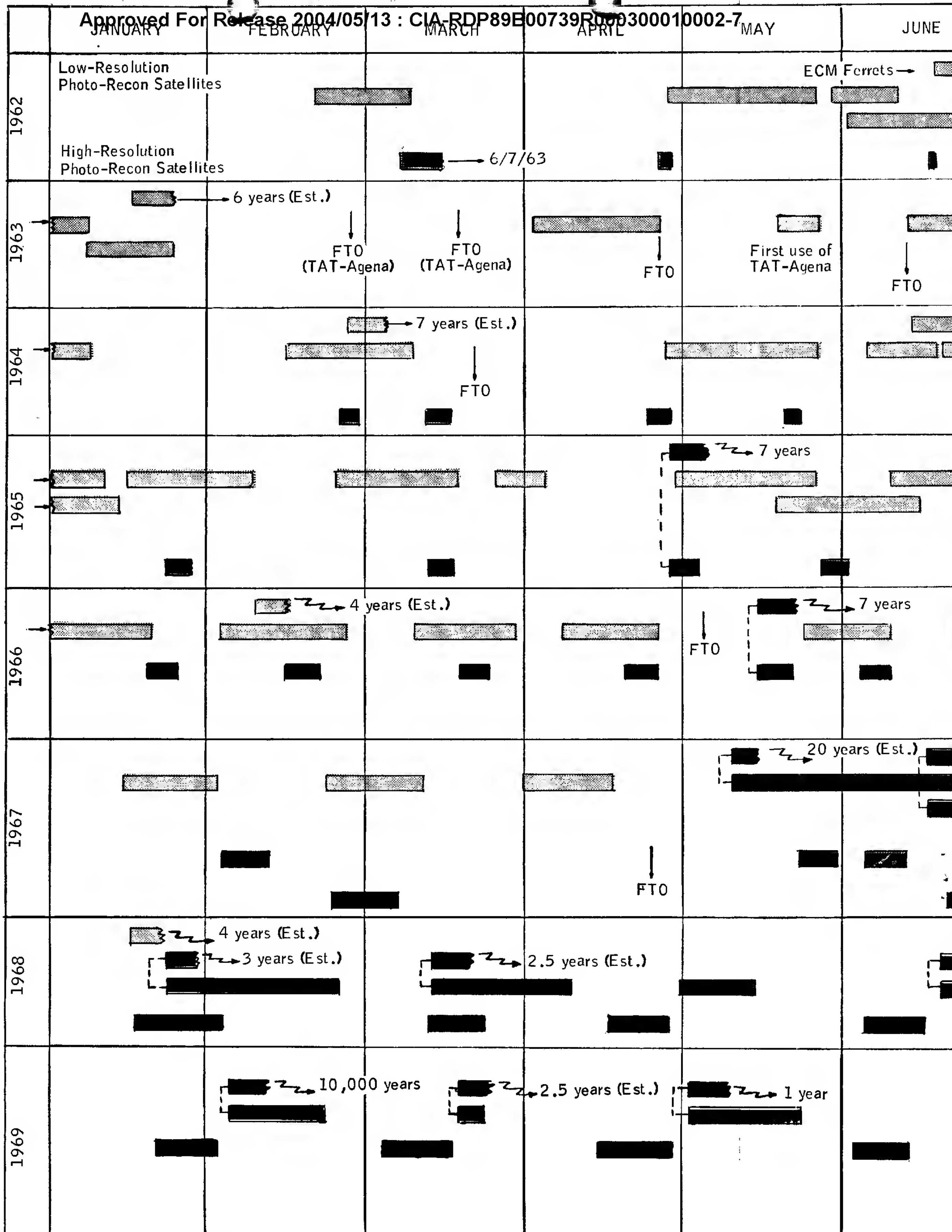
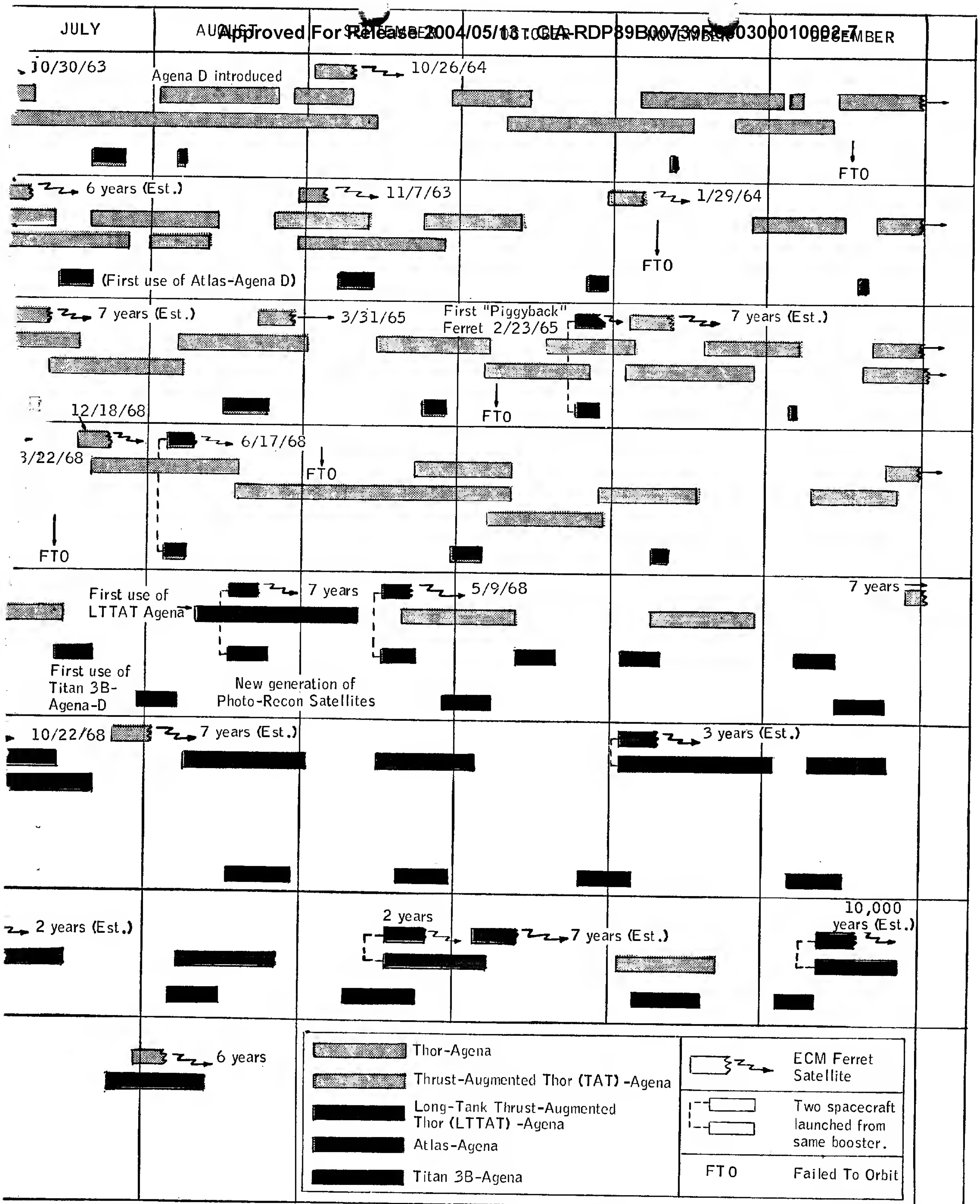


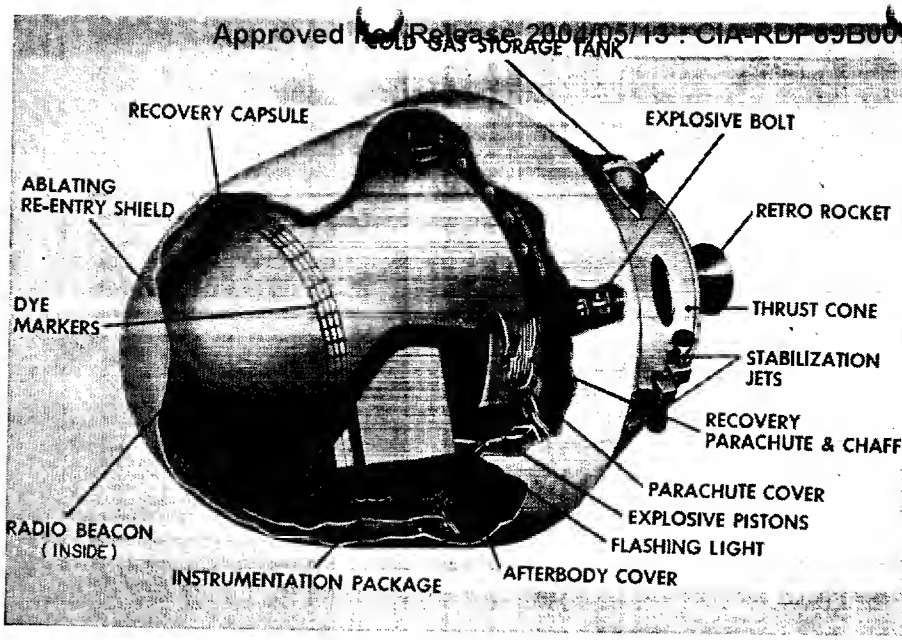
Lockheed Agena-D spacecraft, with unidentified payload believed to be a photo-reconnaissance satellite, is shown undergoing checkout before delivery. Present model, probably a third- or fourth-generation design, is launched by Titan 3B for large close-look photos or by Long-Tank Thrust-Augmented Thor for area surveillance.



Log of U.S. reconnaissance satellite launches, both photo and electromagnetic ferret types, is shown beginning with 1962. Area surveillance photo satellites, which remain in orbit for several weeks before their film pack is recovered and analyzed for objects of potential interest, are launched by Thor/Agena and its more recent thrust-augmented version. Larger photo satellite subsequently is launched to take close-look pictures of objects of specific interest and remains in orbit only for several days before its film pack is



recovered. These close-look photo satellites were first launched by Atlas/Agena-D boosters, but since mid-1967 a Titan-3B/Agena-D has been used. Photo-reconnaissance satellites are marked by low altitude with perigee of about 100 mi. Ferret satellites, which record radar and communications signals, are launched into slightly higher, more circular orbits, with altitudes of 200-300 mi. Ferret satellites, originally launched individually, have since 1964 been launched in tandem with photo spacecraft.



Discoverer re-entry/recovery vehicle, developed by General Electric's Missile & Space Div., is shown in cutaway drawing. Present photo-reconnaissance satellite capsule is somewhat larger to accommodate the camera film pack.

(*Continued from p.* 55)
overlap between successive spacecraft (see chart, p. 57). In this period, there has been an area-surveillance type spacecraft in orbit during approximately half of the days in the year.

The Soviet Union has achieved comparable days-in-orbit coverage since 1966-67 by launching more than 20 of its eight-day satellites per year. There is speculation that some of these are area-surveillance types while others are the close-look variety.

The U.S. close-look photo reconnaissance satellites began to show the regularity of a fully operational system in mid-1963. Their briefer time in orbit docs not require reliability as great as the smaller spacecraft. Since that period, the U.S. has orbited close-look spacecraft at a rate of 8-9 per year, at roughly six-week intervals. A notable exception occurred during 1966 when the U.S. made 12 launches, using the Atlas/Agena-D, as well as three others with the new Titan-3B/Agena-D.

Soviets Act on ABM

It was during this same period that the Soviet Union began to install an anti-ballistic missile system around Moscow and to increase its deployment of hardened ICBMs.

This was revealed in former Defense Secretary Robert S. McNamara's posture statement of Jan. 23, 1967, which said: "Two significant changes have occurred during the last year in our projections of Soviet strategic forces. The first is a faster than anticipated rate of construction of hard ICBM silos. . . . the second is more positive evidence of a deployment of an anti-ballistic missile system around Moscow."

The first of the U.S. electromagnetic ferret-type spacecraft, designed to measure the characteristics of radar and to intercept communications normally limited to line-of-sight distances, appears to have been the satellite launched on June 18, 1962. This satellite was placed in an 82-deg. inclined orbit, with apogee of 244 mi. and perigee of 234 mi., which would take it over most of the military installations in the USSR. These orbital parameters are typical for the ferret spacecraft.

As the electromagnetic intelligence community learned to decipher the jumble of signals received and to refine the spaceborne data collection process, the rate of ferret launches has gradually increased. Two ferrets were launched in 1962, each by a Thor-Agena, four in 1963 and six in 1964. This type satellite is not recovered. Instead it records electromagnetic signals on tape and transmits them back to earth when passing over one of several ground stations. These include facilities in Hawaii, New Hampshire and California.

Piggy-Back Technique

Beginning in the spring of 1965, the USAF introduced a new piggy-back launch technique designed to reduce the number of costly boosters required. An improved performance Atlas/Agena-D was used to boost both a ferret satellite and a close-look photo reconnaissance satellite, each into its own preferred orbit. In the first such launch, the photo satellite was placed in orbit with a perigee of 95 mi., and an apogee of 171 mi.

The ferret was placed in a 303-mi.

Film Capsule Recovery Technique

Difficult technique of mid-air recovery of film capsules ejected from reconnaissance spacecraft, which became the cornerstone of the U.S. spaceborne strategic surveillance program, had a long and discouraging development period.

The Discoverer series of satellites served as a test bed for spacecraft stabilization, capsule ejection and subsequent mid-air recovery by specially equipped Fairchild Hiller C-119 and Lockheed C-130 cargo transports. General Electric's Missile & Space Div. developed the recoverable capsule.

The initial Discoverer satellite was launched Feb. 28, 1959, barely 16 months after Sputnik 1, and was the first to achieve polar orbit. The program appeared to be off to a good start, especially when Discoverer 2, launched on Apr. 13, successfully ejected its capsule. But ejection occurred at the wrong time and the capsule came down in the far north of Norway and was never recovered.

The next two Discoverer satellites failed to go into orbit. Discoverer 6 ejected its capsule successfully but it was not recovered, and the capsule from Discoverer 7 failed to return to earth because of spacecraft stabilization problems. Three of the next five Discoverers failed to achieve orbit and the other two capsules were successfully ejected but not recovered.

Finally, on Aug. 10, 1960, Discoverer 13 was launched and after ejecting the capsule on the 17th orbit, it was recovered from the Pacific Ocean by frogmen after mid-air recovery failed. Eight days later, on Aug. 18, 1960, Discoverer 14 was launched and the first mid-air recovery was made after the capsule ejected during the 17th orbit. The capsule was recovered by a C-119 operated by the 6954th Recovery Control Group based at Hickam AFB, Hawaii.

The technology was not yet completely in hand. The capsule of Discoverer 15, launched on Sept. 13, was lost in the ocean, but the capsule of Discoverer 17, orbited on Dec. 7, 1960, was recovered in mid-air.

By the time the Discoverer program ended late in February, 1962, its record stood at 26 satellites orbited out of 38 launches. Of the 23 attempted capsule recoveries, eight mid-air catches were made and four capsules were recovered from the ocean.

No figures are available on the record of successful recoveries for the operational photo-reconnaissance satellites which began at about the time the Discoverer program ended.

perigee, 349-mi. apogee, giving it a projected life-in-orbit of seven years. The inclination for both was about 95 deg.

The Atlas/Agena-D continued to be used for dual satellite launches until late 1966. On May 9, 1967, the new Long-Tank Thrust Augmented Thor/Agena (LTTAT), which had first been tested the previous summer to launch one of the smaller photo satellites, took over the mission of orbiting the ferret satellites in tandem, but in combination with the smaller photo satellites.

The change presumably was made to accommodate a new, larger generation of close-look photo satellites which would be launched by the Titan-3B/Agena-D, beginning July 29, 1966. By the summer of 1967, the Atlas/Agena had been retired as a launcher of close-look photo satellites, along with this older design of spacecraft.

Since the mid-1967 transition, all of the small ferret satellites appear to have been launched in tandem by the Long-Tank Thrust Augmented Thor/Agena, with three exceptions. One, orbited July 24, 1967, was launched singly with a Thrust Augmented Thor/Agena. The second was launched individually on Oct. 5, 1968 by a LTTAT/Agena. A third was launched on July 31 of this year by what is believed to have been a Thor/Agena, but Britain's Royal Aircraft Establishment is uncertain on this point. Whether these single ferret spacecraft launches indicate a new, heavier satellite design or were merely intended to replace a malfunctioning ferret is a matter for conjecture.

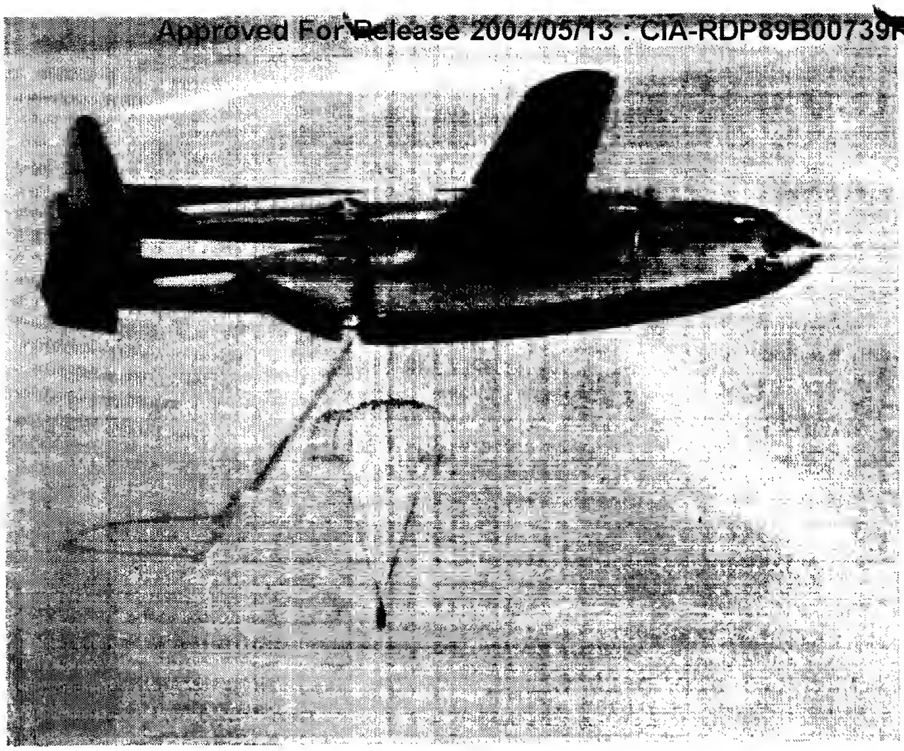
Weight Estimate

The Royal Aircraft Establishment estimates that the standard small ferret spacecraft weighs about 125 lb. and measures roughly 3 ft. in diameter by 1-ft. high. But the Royal Aircraft Establishment emphasizes that these are only gross estimates, presumably based on spacecraft radar echo characteristics and orbital behavior. Some U.S. observers believe the current ferret satellites weigh several hundred pounds.

The weight of current photo-reconnaissance spacecraft can be roughly estimated by several means. In the early 1960s, the USAF released figures on the first three Samos satellite prototypes and on the Discoverer spacecraft which served as test-bed vehicles.

Discoverer satellites launched into near-polar orbit in 1961 using the Thor/Agena-B had weights of 2,100-2,450 lb., including the Agena which contained the payload as well as serving as a second stage. The dry weight of an Agena is about 1,500 lb.

Since that time, the thrust of the Thor has been increased from 170,000 lb. to slightly more than 200,000 lb. in the long-tank version. Another 154,500 lb. of thrust have been added with the



Capsule from Discoverer 13, launched Aug. 10, 1960, was the first to be recovered in mid-air by a Fairchild Hiller C-119. Second successful mid-air recovery, shown above, was capsule from Discoverer 17, launched Nov. 12, 1960.

three strap-on rockets in the Long Tank Thrust Augmented Thor version, for a total thrust approaching 360,000 lb.

One source says the Long Tank Thrust Augmented Thor/Agena-D can place 2,640 lb. in low-altitude polar orbit. Presumably this is useful payload and does not include the weight of Agena engine, tankage and fuel.

When the Atlas/Agena-D was used to launch the Agena vehicle which served as a rendezvous target for the Gemini 10 mission, its weight was listed at 7,184 lb. The 185-mi. high orbit was greater than that employed for reconnaissance missions, but it was placed into a low-inclined orbit toward the east which permits a greater payload than for a polar orbit used for reconnaissance.

Samos Figures

The Royal Aircraft Establishment estimates the weight of the close-look satellites launched by the Atlas/Agena-D at approximately 4,400 lb. Figures released on the original Samos 1-3 show orbital weights of 4,100-4,200 lb., including Agena dead weight. But these original satellites were designed to orbit at 300-mi. so that a somewhat greater payload could be accommodated at the approximately 100-mi. altitudes used in later operational versions.

When the more powerful Titan-3B/Agena-D came into use in the summer of 1966, it undoubtedly marked the introduction of a much more complex photo-reconnaissance satellite since it can orbit nearly 10,000 lb. of payload.

Some idea of the degree of spacecraft complexity that can be achieved within these weight envelopes can be gained by considering non-military satellites designed for less demanding reconnaissance-type missions and equipped with television cameras instead of film. For example, the Mariner 7, which made the recent fly-by of Mars, weighed about 910 lb., the Nimbus 3 weather satellite weighs 1,286 lb. and the Lunar Orbiters each weighed approximately 860 lb.

Considerable portion of the weight of military photo-reconnaissance satellites results from the large film pack, long focal-length optics and the film recovery capsule and its retrograde thrusters.

For example, the General Electric-developed re-entry capsule used in the early Discoverer series, which pioneered the presently used mid-air recovery technique, weighed 300 lb. (see box, p. 58). Presumably, the recovery capsule employed in current operational photo satellites is several times that weight because of its film payload.

While the present arrangement of using two types of photo reconnaissance satellites, one to locate potential targets of interest and the other to make detailed pictures, is working well it has certain inherent disadvantages. One is the large number of photos that must be taken by the surveillance satellite, many of which show nothing of interest. Another is the delay between the taking of these pictures, the time required for their subsequent analysis and the launch and recovery of a close-look type satellite.

The concept behind MOL was that human observers in a manned spacecraft could perform both functions during a single pass, as well as carrying out similar discrimination-judgment functions for electromagnetic reconnaissance. One potential problem was the question of how long a human observer could maintain a keen edge of alertness during such missions. Ground-based tests, using motion pictures taken from high-altitude aircraft and from satellites, reportedly raised some doubts about the ability of spaceborne observers to maintain vigilance for a length of time.

When the USAF originally began its studies of reconnaissance satellites in 1956, as Weapon System 117L, it considered two possible design approaches. One was the use of recoverable film capsules and the other was to employ a television camera whose pictures would be transmitted back to earth.

Transmission Difficulty

The TV camera approach was abandoned for several reasons. One was that the resolution then available was very much poorer than that obtainable from film. Another was the difficulty of transmitting TV photos to the ground. At the very low orbital altitude used, the reconnaissance satellite is not within view of sites where U.S. ground stations can be situated during most of the time the spacecraft is over targets of interest.

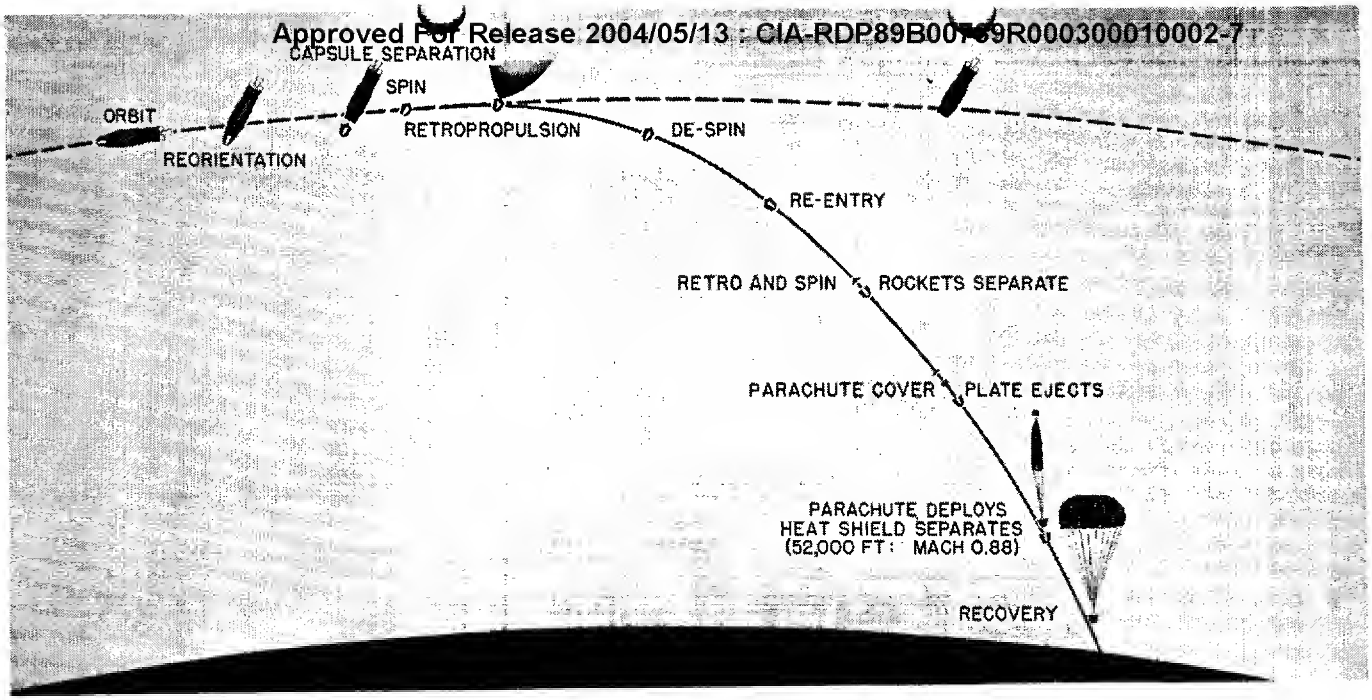
The idea of storing the photos on a tape recorder for subsequent transmission when the satellite passes over stations outside the Iron Curtain was considered, but there were no suitable video recorders at the time.

Technology developed during the last decade has largely overcome these obstacles. New types of videcon tubes for TV cameras now provide resolution approaching that available from film. The last two Apollo flights have demonstrated that a simple, lightweight black/white TV camera can yield color pictures through the use of a simple sequential-scanning optical filter (AW&ST May 26, p. 18).

Television Resolution

One indication of the resolution currently available from television cameras can be found in the lunar surface photos taken by the National Aeronautics and Space Administration/Boeing Lunar Orbiters. The spacecraft TV camera was equipped with a 24-in. focal length lens for high-resolution pictures, considerably shorter than those used in military reconnaissance satellites.

One Orbiter 5 photo, taken from approximately 100 mi., showed the narrow track created by a rolling 15-ft. boulder. Other photos, taken from 30 mi. achieved 3-ft. resolutions. This would be more than adequate in a military reconnaissance satellite to detect signs of hu-



Technique of mid-air recovery of photo-reconnaissance satellite film pack, devised in the early 1960s using the Discoverer satellites as a test bed, is still employed today. But the new generation of area surveillance spacecraft is expected to substitute real-time television pictures which will be relayed via synchronous communications satellite.

man construction activity, such as the preparation of a missile site.

The other basic problem of real-time TV transmission from reconnaissance satellites has been solved with the advent of the synchronous communications satellite which can handle TV transmission bandwidths and remain fixed over one earth position. Such satellites not only can relay reconnaissance photos to U.S. ground stations thousands of miles away, but they can also enable ground operators to switch the spacecraft camera to a different focal length lens or to insert spectral filters designed to penetrate camouflage.

If the relay satellite were parked in an equatorial synchronous orbit over the Indian Ocean, it would be within view of reconnaissance satellites passing over the Soviet Union and Communist China except at very high latitudes. For the polar situation, the relay satellite could be placed in a slightly inclined synchronous orbit to make a small figure-eight ground-track and remain within view of the reconnaissance satellite at all times.

Below Synchronism

The Air Force launched a classified satellite into such an orbit for the first time on Aug. 6, 1968, using an Atlas/Agena-D. The apogee is 24,769 mi., the perigee is 19,686 mi., with an inclination of 9.9 deg., giving the satellite an orbital period of 23.9 hr., slightly below synchronism. This means that it slowly drifts in longitude while making a figure-eight ground track between 9.9 deg. north and south latitude.

There is speculation that this satellite may be a prototype intended to test the real-time relay of reconnaissance spacecraft television photos. Another possibility is that it is a prototype of a Midas-type satellite, designed to provide early warning of an ICBM attack. Conceivably, the spacecraft may be designed to provide both functions.

Early Midas-type satellites operated at about 2,000 mi., but their infrared sensors were misled by sunlight reflecting off high clouds.

TRW Systems is developing for the USAF a new class of military spacecraft, identified as the 949 and known as the Integrated Satellite. It reportedly will provide multiple functions, including ICBM early warning, nuclear explosion detection (now performed by Vela satellites) and possibly reconnaissance photo relay service.

The TRW 949 is not likely to include a photo-reconnaissance capability if it operates at synchronous orbit altitudes, as is expected, since this would require a 200-fold increase in optical focal length to match resolution now obtained at 100 mi. But more insight into the new satellite's mission will come with the initial spacecraft launches, possibly during the coming year.

The Air Force recently awarded a contract to Philco-Ford to construct a new satellite control station on Guam. This western Pacific location would be ideal to receive television photos from a relay satellite positioned over the Indian Ocean. Earlier, the Air Force had sponsored studies of a "satellite control satellite," presumably a relay-type function, at General Electric and TRW.

Lockheed Missiles & Space Co. has just announced that it is building a $1.5-million anechoic chamber to test satellite antennas with diameters of more than 30 ft. Antennas of such size would be needed to receive wideband TV signals from a low-powered transmitter in a reconnaissance satellite.

Large-diameter spacecraft antennas also would be useful in civil communications satellites, especially for direct broadcast. But it seems unlikely that Lockheed would make so large an investment solely in the hope that a civil broadcast satellite market would develop and that it could break the hold of Hughes, Philco-Ford and TRW in the communications satellite business.

Real-Time Reconnaissance

The first use of real-time television reconnaissance can be expected as a replacement for the smaller area-surveillance satellites, now launched by Long Tank Thrust Augmented Thor/Agena boosters. It is likely that film will continue to be used for the close-look, high-resolution satellite pictures for some time to come.

If the television-type surveillance satellites can achieve sufficient reliability to operate for a year or longer in orbit, it will provide major savings in the cost of military launchers and capsule recovery operations, in addition to slashing overall response time.

The first indication that such real-time TV reconnaissance has become operational will be the end of the launches of the smaller photo satellites. As of now, they are still being deployed.

The most recent launch occurred on July 24.

The DC-10 takes Goodyear's total braking systems approach

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